# From Technoscience to Geostrategic Technoscience

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Abstract

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The purpose of this document is to establish, based on the revision of the *"Technoscience"* concept, the formulation of the *"Geostrategic Technoscience"* concept; which allows contextualizing the philosophical-scientific understanding of the role of science, technology and innovation (STI), within the framework of international relations between countries and between them with private corporations at the beginning of the 21st century, in the field of Science, Technology and Society (STS). The article concludes, based on Geostrategic Technoscience, that current studies of the philosophy of science and technology need to link the geostrategic relationships between the different countries, considered as powers, taking into account the integration of research practice between sciences, technologies and innovation, in a mega industrial production complex, which articulates scientific and technological knowledge with the innovation of goods and services, in the dynamics of corporate economic production, national defense systems and international legal-political relations between States, among other high number of links that are also analyzed.

Keywords: Technoscience, Geostrategic Technoscience, Geopolitics, Geostrategy

[1] This article was originally written in Spanish. The original text can be found at: https://repositorio.unbosque.edu.co/bitstream/handle/20.500.12495/6954/Ochoa.Rojas_Luis_Francisco.pdf?sequence=1

## Introduction

The drastic changes that have been taking place since 1990 in the world, in all fields of human activity and their relationship with the planetary environment, including STI and social practices with the use of new technologies, require new perspectives, reflections, and courses of action due to the limit scenarios that all nations are approaching. Scenarios in which signs of crisis are evident in the current civilization, a crisis that manifests itself in the greatest threats to the viability of societies and the global terrestrial ecosystem; issues that require proactive reflection, from the philosophy of science and technology, about these problems and highlight their interconnection. Therefore, a detailed reflection is justified, as proposed here, to encourage decisions that modify the current course of events.

Therefore, it is worth starting by saying that since World War II, science has undergone a true mutation, building a hybrid with engineering and technology, a process that has generated R&D systems (scientific research and technological development). This combined with the emergence, starting in 1940, of *Big Science* (Price, 1973 and 1986), known in Spanish as *Mega ciencia* and *Macro ciencia*. The term was first used by Alvin M. Weinberg (1961) in an article analyzing the impact of large-scale scientific activities in the United States, reflecting on: a) the new social structures built by the new technology, about the effects of organization and financing of *Big Science*; b) the nature of scientific research; and c) the competition established between the US and the Soviet Union, as one of the manifestations of the Cold War.

These aspects later sparked a movement of criticism towards militarized science, giving rise to the *social turn*, which crystallized in the late 60s in the transdisciplinary studies of STS (science, technology, and society), led by some American philosophers, to denote a search for the "unity" of knowledge, integrating it into a single meta-disciplinary epistemic perspective.

One of such philosophers was Carl Mitcham (1989), who advanced one of the first serious attempts to systematically delimit the scope of the philosophy of technology. This author subsequently presents a critical introduction to the philosophy of technology (1994), providing a historical and philosophical vision, arguing for the need to distinguish two traditions: a) the philosophy of engineering technology, which emphasizes the analysis of the internal structure or nature of technology; and b) the philosophy of technology of the humanities, which deals more with external relationships and the meaning of technology. He also provides a basis for uniting these traditions by conducting a humanities analysis across the broad spectrum of engineering and technology (Mitcham, 1994). The argument is that the philosophy of technology of the humanities is the most philosophical tradition, but it has not consistently or in detail paid attention to what actually happens in engineering and technology.

Other philosophers participating in the social turn project are Paul T. Durbin et al. (1983), who note that, as a result of the complex structure of modern technology, it can be approached in very different ways, from studies that range from the metaphysical exposition of its objects to efforts aimed at achieving political consensus on its possible developments. According to these authors, the global impact of technology, its penetration into all spheres of individual, social, and cultural life, together with the urgency of the problems raised in this context, all demand a joint philosophical discussion that transcends language barriers and cultural differences. Studies and reflections that, although given independently, by their origins and objects of analysis, present some parallelism between this field and other types of cultural studies and the constructivist view of science.

In another perspective of analysis, Ian Hacking (1996) showed that epistemology and methodology were not sufficient to understand science and that a *philosophy of scientific practice* was necessary, in which four contexts of scientific activity (education, research, application, and evaluation) could be distinguished, which allowed differentiating science from technoscience, and for the same reason, philosophy of science from philosophy of technoscience.

In this context, Channell (2017) asks: Are science and technology independent of each other? Does technology depend on science, and if so, how does it depend? Does science depend on

technology? If so, how does it depend? Or have science and technology become so interdependent that the line that divides them has been completely blurred? In the same book, the author traces the history of technoscience from the late nineteenth century to the late twentieth century and shows how the military-industrial-academic complex and *Mega science* combined to create new examples of technoscience in areas such as the nuclear arms race, the space race, the digital age, and the new worlds of nanotechnology and biotechnology. Thus, he establishes the relationships between the two fields from a terminological perspective. In the same work, he examines the roots of technoscience from the perspectives of industrial-based science and science-based industries, taking into account the production of chemicals, plastics, synthetic dyes, pharmaceuticals, industrial research laboratories for electricity, light, radio, and telephony services, among the most outstanding. He continues with the description of the scenario of the military-industrial complex given in World War I. He then describes the scenario between the First and Second World Wars, which he considers the preparation of the context for *Big science*, highlighting research and development in aviation, rocketry, chemistry, as well as research in nuclear physics. He then examines the emergence of the military-industrial complex within World War II, in which research on uranium, radar, pharmaceutical chemistry, the first military computers, and the atomic bomb will be the first great products of *Big science*. Subsequently, he describes the gradual emergence of technoscience as nuclear arms race programs, the Hydrogen Bomb, nuclear reactors, high-energy physics, the space program, the race for missiles (intercontinental ballistic missiles), the space race, the race for the first manned landing on the moon, astronomy, planetary science, and astrophysics are developed. He then analyzes the field of electronics, with the development of general-purpose computers, the transistor, integrated circuits, and computer science. He then outlines the course of the science of new materials, lasers, superconductivity, and nanotechnology. Finally, he discusses biotechnology, in which he describes advances in genetics and the double helix, the genetic code, genetic engineering, and the Human Genome Project. He concludes with some considerations around the new world that opens up around technoscience (Channel, 2017).

The developments mentioned during the 20th century have surpassed the comprehensive capacity of the philosophy of science of logical empiricism and the *Received View*. This is due, among other aspects, to the scarce attention that philosophers of science have devoted

to the science that began to be practiced after the Second World War; keeping their attention focused on the theoretical-epistemological, logical-semantic, and methodological aspects of scientific activity at the beginning of the 20th century. Other authors have done so from other theoretical-scientific perspectives, particularly historians of science such as Galison (2008), who says that large-scale scientific research (*Big Science*) in the second half of the 20th century is difficult to ignore. Coordinated large-scale science occupies entire regions of the United States. Defense laboratories cover thousands of acres and employ tens of thousands of workers. Some particle physics accelerators surround entire cities. *Big Science* becomes part of public debate, including in citizen life and public opinion, projects of "big physics" of "small particles", research funded by external interests, and national defense anchored in *Big Science*.

For his part, scientometrician Derek de Solla Price (1963, 1973, and 1986) recounts the transformation *from Little to Big science*. That is, the passage of time from studies with individual researchers or small groups to mega-projects that employ thousands of people with multiple roles. This issue leads to measuring the results of scientific production. By elucidating the social and cognitive arithmetic of science, this author did a lot to lay the foundations of the research field dedicated to the quantitative analysis of science and scientific development, the field known as *scientometrics*, or sometimes *bibliometrics*.

Regarding the link between the economic system and science and technology, Leydesdorff (2010) points out that the concept of a *knowledge-based economy* was introduced at a European summit held in 2000, sponsored by the Organization for Economic Cooperation and Development (OECD), which sought to agree on a new strategic objective for the European Union in order to strengthen employment, economic reform, and social cohesion of the member states. This shows how scientific and technological activities are key components for generating new knowledge, developing devices or artifacts and their innovation, which impact the dynamics of economic relationships. It is a model that involves university-industry-government relationships, which are compared with alternative models to explain current transitions in the research system in their social contexts. Leydesdorff and Meyer (2003) say that such relationships are like a "triple helix", which constitutes a model of the innovation process that is susceptible to measurement. Economic exchange,

intellectual organization, and geographic constraints can be considered as different dynamics that interact in a knowledge-based economy as a complex system.

In the perspective of the critical sociology of the *Frankfurt School's* second generation, Habermas in *"Science and Technology as 'Ideology'"* ([1968]1999), in the essay that gave this book its name, establishes a discussion of Marcuse's thesis (1941 and 1965) on the instrumental function of technology in society. In the chapters *"Work and Interaction"* and *"Progress, Technology, and Social World"*, the central recurring theme of the work is explained, which has its origins in Hegel, referring to the idea that work and technological progress [technologies linked to scientific and economic production] must respect the laws and customs of social coexistence.

In the view of French authors, it is worth mentioning Ellul (1964, 1980, 1990) and his studies on the development of technology, its history and its link with economies; his analysis of technology as a concept, as a system, its features and the characterization of technological progress; his reflections on the cynical willingness to be blind to what technology actually does and says, a matter he calls the *bluff*: a well-argued and well-justified attack against the hypocrisy and obsolescence of the official apology of technology and technology.

Bourdieu (1976) refers to power tensions within the scientific field, understood as a system of objective relationships of positions acquired in scientific communities, to claim authority regarding what is said or asserted in certain areas of knowledge and technology, so that such authority generates legitimacy and capacity for action, which translates as power. He suggests that the scientific field, understood as a system of objective relationships between positions of power acquired in previous struggles, is the playing field of a struggle between competitors, whose specific interest is the monopoly of scientific authority. Authority that is inseparably defined as technical capacity and social power. In other words, the monopoly of scientific production capacity, understood in the sense of the ability to speak and act legitimately, that is, in an authorized and authoritative manner, on matters of science and technology, with which a particular agent is socially recognized, can be understood as scientific power.

Hottois (1991), referring to technoscience as a pendular theoretical realm that oscillates between technophilia and technophobia, states that technoscience carries out the modern

project, i.e., through it, societies become masters of nature. But at the same time, they are profoundly destabilized because they tend towards their own depredation. This happens because under the name "nature," it is also required to conceive of all the components of human subjects, such as their nervous system, genetic code, cortical computer, visual and auditory sensors, communication systems, especially linguistic ones, and their group life organizations, among other attributes. From this, it follows that their science and technoscience are also part of nature. This idea recalls not only the objectification of the body, including the brain and genome, but also the technoscientific objectification of the relational capacities of subjects that constitute intersubjectivity and subjectivity, which involve the use of language, social interactions he calls sociality. What the author describes here assumes the end of the opposition between symbolic culture, language-thought, on the one hand, and physical or material techniques and natures, on the other. The above, including everything that traditionally belonged to the mind, i.e., ideality, transcendence, and immateriality, is naturalized, materialized, and technologically operable.

Simondon (1989, 2005, and 2014) expresses his ideas with the purpose of conceiving technology within the framework of a general theory of the living and of humans as living beings. His main thesis is the philosophy of technology from the perspective of individuation, based on the mode of existence of technical objects. This philosophy of artifacts must be approached in the context of his philosophy of the living. This means that the mode of existence of technical objects must be understood in relation to individuation, in light of the notions of form and information. Simondon develops his argument both in relation to physical individuation, as well as biological, psychological, the principle of cohesion of societies, and a prescriptive ethics. It is a new metaphysics, a new vocabulary for thinking.

Taking this into account, it is necessary to indicate that the concept of French-speaking thinkers on technoscience was proposed in the 1970s (with some precursor ideas in the 1950s) in contrast to the vision of dominant analytical approaches in the philosophy of science. Unlike these approaches, which treat science as a language and representation activity, that is, a manipulation of symbols and theories, it was important to recognize the importance of the non-conceptual aspects of science. Work multiplied from the 1980s, precisely emphasizing these non-linguistic and non-symbolic aspects of science. However, it

is clear that the concept of technoscience has gained more confusion than precision. For example, Joly (2013) says that there is no common concept of "technoscience", what is found is a family of related meanings.

From an ethical perspective, Hans Jonas (1995), taking the crisis of modernity as his horizon of analysis, examines technological society with a meticulous attitude. In this study, he highlights that the only known being endowed with responsibility for its actions is human. Only human beings can consciously and deliberately choose among various alternatives of action. This choice has clear consequences, which translate into responsibility for the one who has chosen. In that sense, responsibility embodies freedom at the same time. Responsibility is a duty, that is, it is a moral requirement that runs through the entire vision that has been constructed throughout the history of Western culture. This has become a manifest requirement because, in the conditions of contemporary technological society, responsibility must be coupled with the power that humanity has over the world. Thus, it could be said that *power implies duty*. He says that human action has dramatically transformed in the 20th century. This mutation is related to technoscientific developments and the collective characteristic of action. This has led to nature and humanity being in danger. In earlier times, human action in the natural environment was minimal, which kept it in harmony with the normal cycles of the natural world. Currently, the growth and extension of artificial systems, incompatible with the dynamics of natural systems, places the maintenance of the planetary biosphere at risk. It is a growing and predatory technoscientific cosmos that breaks the dynamics of self-preservation and the re-equilibrium of the planetary ecosystem, threatening extinction. Becoming aware of this situation requires assuming responsibility and therefore changing the direction of technoscientific action. It is then worth asking whether the natural system of life can have its own moral right. Its defense is a task of responsibility. This reflection is not simply juridical, but fundamentally ontological and ethical. From it derives the sense of responsibility towards others: the countless beings of nature and human descendants. It is an ethics towards the future, in which there is a deontological element that finally poses an imperative. This arises from the new conditions of life caused by the technological threat. The moral responsibility arises from the vulnerability of nature subjected to human intervention techniques, as well as from a Kantian *a priori* of respect for life in all its forms.

However, from another branch of analysis, experts in scientific policy serving the planning and development programs of different countries have approached the study topic with a pragmatic spirit. This happened from the beginning, with scientific policy pioneer Vannevar Bush, who in July 1945, in his report to the President of the United States on a post-war scientific research program, said:

> Progress in the war against disease depends upon a flow of new scientific knowledge. New products, new industries, and more jobs require continuous additions to knowledge of the laws of nature, and the application of that knowledge to practical purposes. Similarly, our defense against aggression demands new knowledge so that we can develop new and improved weapons. This essential, new knowledge can be obtained only through basic scientific research. Science can be effective in the national welfare only as a member of a team, whether the conditions be peace or war. But without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world. (5)

Such a way of seeing things opened a new scenario in the planning of scientific and technological development, by linking it to the production of goods and services. The same would happen with the strengthening of the country's defense system in the production of weapons. Bush was clear that basic scientific knowledge and the development of application technologies were essential for the maintenance of post-war American stability. This was only possible through research, which involved an activity carried out by teams of people in large facilities and with planned financing, which involved private contractors. It followed that without scientific and technological progress, it would be difficult to achieve success in other fields that could ensure American health, prosperity, and defense as a strong nation in the modern world.

This vision of scientific and technological policy emerged from the results of World War II, including the occupation of Germany, after the fall of Berlin, in which Americans encountered a voluminous scientific, technical, and instrumental content that was seized. This content included personnel such as scientists, engineers, technicians, and academics, who were secretly transported and nationalized, the collection of nearly one million scientific articles, numerous patents, and a huge amount of looted devices transported to the United States, in which the respective Nazi plans were identified (Walker 1946, Crim 2018, Samuel

2004, Gimbel 1990a, Gimbel 1990b, Gimbel 1986, Bernstein 2001, Hunt 1985, and Jacobsen 2014).

This is the first foray into the notion of a scientific policy for times of peace, which later became the scientific policy of countries and served as an example for other nations. Regarding this, Echeverría Ezponda says the following:

> Since then, it has been developed and spread throughout the most developed countries. Thus, a new type of techno-scientific action emerged: the design, discussion, approval, publication, and implementation of Science and Technology Plans, with the subsequent creation of specific agencies for this purpose. These plans are proposed by Governments and, where applicable, debated and approved by Parliaments. They are political actions in the fullest sense of the word. They are usually considered matters of State, around which a broad consensus is sought among various social and political agents. Through these actions, the world is also transformed, but not the natural world, but rather a sector of the social system, namely the scientific and technological systems (STS) of each country. Science and Technology Policy (STP, for short) promotes, develops, and transforms the context in which scientists conduct research and technologists innovate (2003 45).[2]

That is why publications on science and technology have gained increasing importance in the last decades in different nations worldwide. The academic and intellectual environment of science and technology studies is currently dominated by reports and diagnoses produced on these topics, which carry much greater weight than the writings of historians and philosophers of science when it comes to making decisions on public policies on science and technology and their consequences for the practice of research in STI.

This literature emerged due to the commitment of various countries to design and implement economic and social development plans following the premises that began to guide US science and technology policies after World War II, in the context of the reconstruction of

[2] Original text: "Desde entonces se ha desarrollado y difundido por los países más desarrollados. Apareció así un nuevo tipo de acción tecnocientífica: el diseño, discusión, aprobación, publicación y puesta en funcionamiento de Planes de Ciencia y Tecnología, con la subsiguiente creación de Agencias específicas para ello. Dichos planes son propuestos por los Gobiernos, y en su caso debatidos y aprobados por los Parlamentos. Se trata de acciones políticas en el pleno sentido de la palabra. Normalmente son consideradas asuntos de Estado, en torno a los cuales se busca un consenso amplio entre diversos agentes sociales y políticos. Mediante esas acciones también se transforma el mundo, pero no el mundo natural, sino un sector del sistema social, a saber: los sistemas científico-tecnológicos SCyT de cada país. La política de ciencia y tecnología (PCyT, para abreviar) promueve, desarrolla y transforma el contexto en el que los científicos van a investigar y los tecnólogos a innovar (2003 45)."

Europe (Marshall Plan). This matter was concentrated in the Organization for European Economic Cooperation (OEEC), which would later become the *Organisation for Economic Co-operation and Development* OECD in 1960 when twenty countries from North America and Europe adhered to the "OECD Convention" held in Paris on December 14, 1960. The organization issued guidelines on economic development planning that linked research, development, and innovation (R&D&i), in line with the provisions of other international institutions such as the UN, World Bank, and International Monetary Fund. Currently, the OECD has become one of the most influential global forums, analyzing and establishing orientations on internationally relevant topics such as the economy, education, and the environment (OECD, 2020). Its direct and derivative technical documentation regarding scientific production and technological development indicators is internationally accepted by governments, academic institutions, and scientific and technological communities, as it provides guidance for the collection and presentation of information on research and experimental development carried out in countries (OECD, 2015), guidelines for collecting and interpreting information on innovation (OECD, 2018), and standardization of technological innovation indicators in Latin America and the Caribbean (RICYT-OAS, 2001).

Changing perspective, in this case from the sociology of scientific knowledge, authors such as Latour and Woolgar (1995) conducted a two-year study at the Salk Institute for Biological Studies. Latour became part of the laboratory, closely following the intimate and daily processes of scientific work, while remaining an external observer who was inside. This was a form of ethnographic research to study the detailed scientific practice of the tasks that scientists perform in a laboratory and thus uncover what and how they think. Latour (1992, 2001, and 2008) respectively works on how to follow scientists and engineers through society, in the dynamics of science studies and Actor-Network Theory (ANT). Meanwhile, Pickering (1993) reflected on the emergence and action of the sociology of science, addressing the issue of scientific and technological practice. Nowotny, Scott, and Gibbons (2001) presented a description of the dynamic relationship between society and science. They felt that the series of arguments aimed at persuading society to support science has not sufficiently taken into account the developments that have taken place, whether in society or in research, which are discussed in academic and political literature as well as the press.

Despite evidence of a much closer and interactive relationship between society and science, the authors insist on the need to maintain a demarcation between them. Finally, Nowotny (2015) pointed out that in the summer of the same year, Carlos Moedas, the new European Commissioner for Research, Science, and Innovation, presented his vision for the future of science and innovation in Europe. He identified three challenges that EU member states will face in the coming years. First, Europe is falling behind in the transfer of research results to new products and services: too often, new technologies developed in Europe are commercialized elsewhere. Second, Europe needs to improve the quality of its research output: although the EU generates more results and scientific publications than any other region in the world, it does not capture a proportion of highly cited or historically impactful publications. Third, Europe is punching below its weight in international science and scientific diplomacy: Europe's voice should be more actively raised in global debates.

All the authors and publications mentioned above allow us to establish a panorama for the effects of this article. Of course, these constitute a sample of the immense universe that exists on the subject. Given the above, and for the purposes of this text, two authors who deal with the topic of "technoscience" from different yet interrelated perspectives have been chosen: Bruno Latour and Javier Echeverría Ezponda. Each has useful contributions, similarities, and differences. The line of argument is to present each author's respective conceptions and then formulate a reworked conceptual proposal for "technoscience." Following this, based on the international relations of the early 21st century (geostrategy), a composite concept will be proposed, which will be called "Geostrategic Technoscience."

Given what has been presented so far, the following question is worth considering: What meaning of *Geostrategic Technoscience* can be elaborated and assembled, based on the revision and reworking of the concepts of *Technoscience and Geostrategy* for their use in the Philosophy of Science and Technology, which can represent systematically the existing relationships between Science, Technology and Innovation (STI) at the beginning of the 21st century?

## About the Technoscience concept

Having reviewed a considerable amount of authors who refer to the philosophy of technology, the philosophy of science that links technology, and technoscience, it has been considered to approach the concept of technoscience in the authors Bruno Latour and Javier Echeverría Ezponda. This is because both authors address the concept in detail and from different perspectives that may be useful for proposing a concept such as *Geostrategic Technoscience.*

### *Technoscience in Latour*

Bruno Latour proposed the term *technoscience* to emphasize the deep connection between science and technology in the 20th century. This author inherited the philosophical use of technoscience suggested by the French philosopher Gaston Bachelard (1953) through the concept of *phenomenotechnique* (Martins 1998, Gómez 2015). Later, it was extended in the French-speaking world by the aforementioned Belgian philosopher Gilbert Hottois (2000), and entered academic use in English with the book *Science in Action* by Bruno Latour (1988a).

In his Actor-Network Theory (ANT), he proposed the existence of non-human agency, that is, technological agency in research activity, which justifies the use of the term "technoscience" instead of "science" (Latour 1992). Science and scientific policy have become technological because society itself has become increasingly infused with technology. To understand this Latourian concept, it is necessary to synthesize ANT.

Latour (1988b) attempted to show the simultaneous construction of a society and its scientific and technological facts; he did this by illustrating the case of the history of Pasteur, which is a vivid description of a science approach whose theoretical implications go far beyond a particular case study. Similarly, presenting the innovation of the management of hotel room keys in Europe and the invention, as well as the development of the Kodak camera, along with the emergence of the mass market of amateur photographers (Latour, 1991). With these examples, among others, he proposes to present the relationship of life facts with technological innovations. This is one of the characteristics of ANT, starting from the

description of facts and associations to give an explanation, in this case, of what refers to science and technology as builders and cohesioners of the social. As it illustrates a case, it characterizes the associations or links established between different components, human and non-human (also known as actants), which constitute what traditional sociology calls "social."

The so-called "social" is not a material or substance, although it can be conceptualized as a phenomenon susceptible to study. Latour (2008) seeks to redefine the notion of the social by returning to its original meaning, which refers to the identification of links that constitute the interactions between the natural and artificial components of societies. In this vision, he rescues the search for connections between elements using more appropriate tools in the investigative process. In other words, if understood as a process of associations, the social is susceptible to study, for the purposes of understanding, although not prescriptive. In this way, he conceives that the investigative activity of the sciences and the development of technologies are a fabric of links and associations that build one of the manifestations of the social.

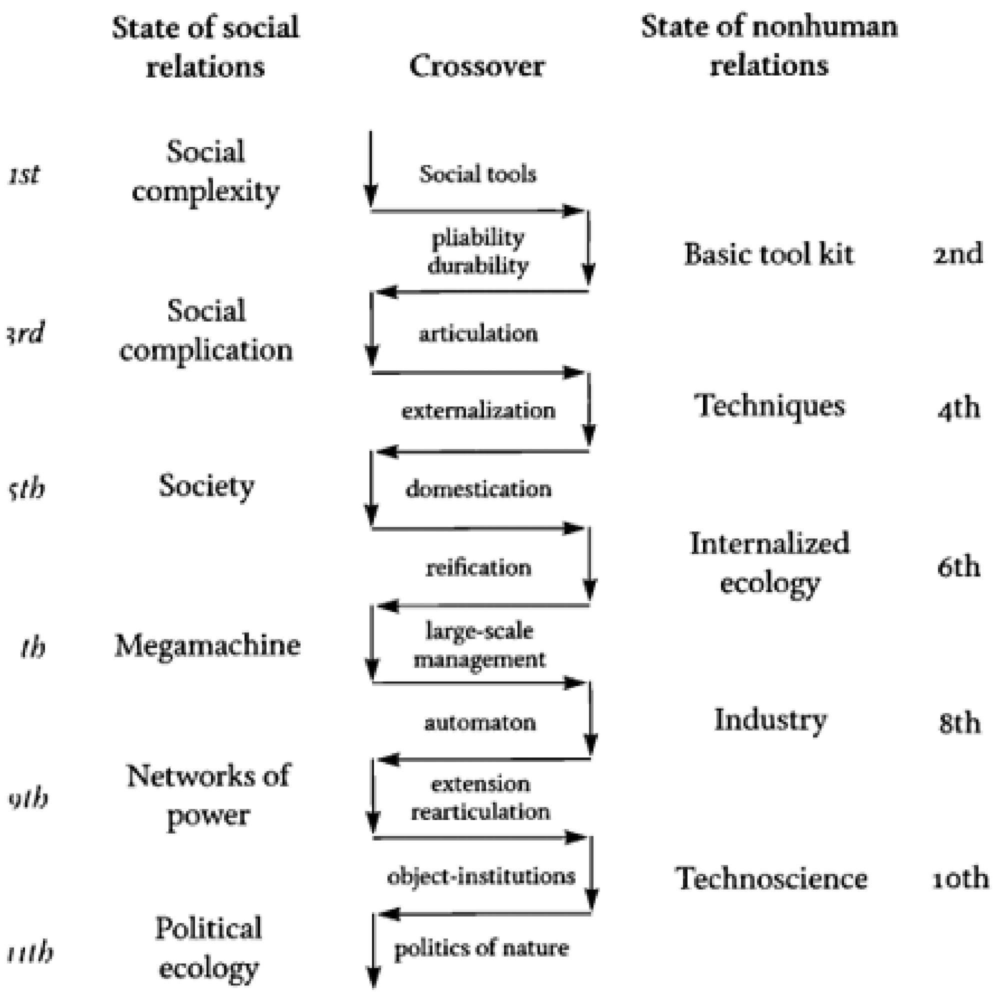
This new way of viewing science and technology studies emerged linked to the urgent need to account for science in the context of societies. That is why political ideologies, economic interests, or prejudices that existed in social imaginaries became worthy elements of inquiry through the tracing of their associations to explain the origin and legitimization of scientific theories (Latour 1991, 1998). This was done to express how nature works in the set of sciences that concern it and, thus, defend a constructivist socio-epistemic revolution that challenged the realist-based epistemic analytical tradition. Despite this, different authors disagreed with the "sociology of the social" and with the "principle of symmetry"[3] proposed by Latour, defending the thesis that the "social context" lacks real explanatory power and that such a principle has limits. Unlike what was proclaimed and practiced at the Universities of Edinburgh[4] and Bath[5] (Gatica 2015), followers of Latour and Woolgar's vision and the *Strong Programme in the Sociology of Knowledge*, natural and social phenomena occur

[3] According to Latour, people and machines should be treated as equals in order to conduct social studies. That is to say, he considers it a mistake to approach explanations that refer to dualisms such as nature-social or human-nonhuman.
[4] David Bloor, Barry Barnes, Harry Collins, Donald A. MacKenzie & John Henry.
[5] Collins, Pinch & Travis.

simultaneously and interactively (García Díaz 2008, Pozas 2015, Monterroza 2017, and Larrión 2019).

According to Latour, the Actor-Network Theory (ANT) allows for an analysis of the scientific and technological, considering three criteria: a) that in the tracing of networks and associations, it is necessary to include human and non-human actors; b) that to explain the stabilization of networks, the abstract concept of the "social" should not be used; and c) that an analysis can be considered proper to the ANT if its objective is not deconstruction, but the re-composition of the social (2008). He emphasizes that the ANT is not a critique of the grand narratives [about science and technology]; its objective is not to deconstruct or destroy them but to identify the new institutions, procedures, and concepts that favor the reconnection of the social.

In the context presented about the ANT, Latour (2001) proposes the concept of technoscience in his book *Pandora's Hope*, in chapter 6 (*A collective of humans and non-humans*). He does this in the staging of a theory about the relationships between humans and objects over time. According to the author, objects and subjects exhibit a greater intertwining in the future than they have possessed in the past. Therefore, there is a feeling of instability in a dynamic in which the link between humans and non-humans is increasing. He says that along the arrow of time, the successive intertwinements that have facilitated the exchange of properties between humans and non-humans are highlighted. Each of these entanglements leads to a transformation in the magnitudes of the collective between humans and non-humans, both in composition and degree of cross-linking. He thus constructs a dynamic of intertwinement that goes from the present to the past, in which the components of such crossings are the "states of social relations" with the "state of non-human relations," ranging from degree 1 to degree 11. At degree 10, he locates *Technoscience*, which is linked to the *Power Networks* that correspond to degree 9, through *object-institutions*. Similarly, *Technoscience* is linked to *Political Ecology* that corresponds to degree 11, through nature policies, following the indicated sequence of entanglements. The following graph illustrates this:




Graph 1: Technoscience in the intersection between social relations and non-human relations
Source: Latour, Bruno. *Pandora's Hope* (2000 213)

In this framework, Latour (2001) says that:

> Gracias a la tecnociencia -definida, para los objetivos que aquí me propongo, como una fusión de ciencia, organización e industria-, las fórmulas de coordinación que aprendimos a lograr mediante «redes de poder» (véase el nivel 9) se ensanchan ahora hasta abarcar a las entidades no articuladas. Los no humanos están dotados de habla (por muy primitiva que sea) y de inteligencia, capacidad de previsión, autocontrol y disciplina, todo ello organizado de una forma que es simultáneamente íntima y apta para actuar a gran escala. La cualidad de ser seres sociales es algo que compartimos con los no humanos de un modo casi promiscuo. Aunque en este modelo -que constituye el décimo significado socio técnico […]-los autómatas no tienen derechos, son ya mucho más que entidades materiales: son organizaciones complejas (244). [Que sugiere] a gestionar elplaneta en que vivimos, y lo que nos toca ahora definir es […] "una política de las cosas" [véase nivel 11: Ecología Política] (243).

In this quote, Latour suggests that technoscience (the fusion of science, organization, and industry) has allowed non-humans, such as machines, to be considered entities with speech, intelligence, and organizational capacity. This implies that humans should consider machines and other non-humans as equals in terms of their ability to influence society and the environment. Additionally, Latour argues that the management of society and the environment should include a "politics of things," which means that we must pay attention to how objects and technology affect and are affected by society and the environment. In this approach, automatons (machines) do not have rights, but are considered complex organizations that must be managed in terms of their impact on society and the environment.

From what can be inferred, for Latour, *technoscience is the intertwining between the activities of scientific and technological research processes, with the technical administrative organization of research management, through large-scale power networks in which humans and artifacts (non-humans with the possibility of acquiring rights) interact, within the framework of complex organizations of industrial production processes of goods and services associated with them, which are regulated by a political ecology.*

*Technoscience in Echeverría Ezponda*

In reflections on the development of science and technology in the 20th and 21st centuries, specifically since the end of World War II, this philosopher of science has been interested in studying the transformations and impacts, from an evolutionary conception (Echeverría Ezponda 2003), around what he has called the "technoscientific revolution."

In this "revolution" in which science and technology are main actors, the concept of "technoscience" has emerged, which Echeverría Ezponda (2003) develops from historically previous concepts such as *"Little Science"* and *"Big Science"*, which throughout this article is called "*Mega Science*". Hence, a synopsis of the migration or transformation of the phenomenon of science and technology is presented, from the classical view of science, through the characterization of Mega Science and its transformation into Technoscience with its characteristic features.

Echeverría Ezponda (2003) states that the expression *"technoscience"* is controversial. It is viewed with suspicion by the community of researchers in basic sciences because the compound word seems to give preponderance to the technical, technological, and applied research aspect. From philology, it seems like a barbarism, as it combines the root *"techno"* derived from the Greek *τέχνη* (tekhné = art, technique, or profession), and science comes from the Latin *"scientia"* (knowledge). He adds that philosophers of science remain convinced that well-defined demarcation lines remain between science and technology, as it could happen that when talking about *technoscience*, the nature of science itself could disappear, overrun by technology. Sociologists of science use it as a technical expression, and the precise delimitation of the term allows us to understand and reveal the notable transformations that have occurred in scientific-technological activity during the 20th century (2003 22).

By making a quick history of scientific activity from the 16th to the 20th century, Echeverría Ezponda (2003) describes a process about the development of technoscience called the *"technoscientific revolution"*. This is a new way of doing science, which is located at the beginning of World War II with the *"Manhattan Project"*, which allowed the design, development, and production of the atomic bomb. In addition to this, other projects such as the *Berkeley Radiation Laboratory, the M.I.T. Radiation Laboratory, and the ENIAC project at the Moore School of Pennsylvania* can be cited. This revolution was consolidated during the Cold War (1945-1990), extending to other countries such as Japan, Canada, and several in Europe. Here, research based on small groups of scientists *(Little Science)* with academic emphasis transformed into large and complex industrial structures in which thousands of people participated with different roles in the research, development, and production process *(Big Science).*

The author focuses on the American case[6] because its influence has been decisive and has served as a model for other countries, which have followed a process of emulation of the North American experience. He divides the process into three stages as follows:

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[6] It should be noted that the processes experienced by the Union of Soviet Socialist Republics (USSR) or the People's Republic of China in the field of STI are not addressed in the development of this article, as they correspond to events and phenomena that go beyond the limits established for this work.

a) From 1940 to 1965, Big Science or mega science emerged, which is considered as a previous stage to the appearance of technoscience. Basic research in physics, chemistry, and mathematics was the driving force behind this *first stage*, as well as military participation in the direction of megaprojects.

b) Between 1966 and 1976, a *second stage* emerged characterized by stagnation, mistrust, and social and intellectual agitation in the United States and Europe due to the abuse of American military power in the Vietnam War and its resounding failure, in which the results of "macro science" were used in military actions. "Public investments in R&D grew steadily until 1966, when a major crisis occurred, coinciding with the arrival of the Nixon Administration" (2003 18). This is a transition stage between "macro science" and technoscience.

c) In the last 25 years of the 20th century, the author points out the emergence of the *third stage*, which he refers to as technoscience proper. In this stage, research and development leadership is taken over by business consortia, leaving the federal government in a secondary role. This is where private contracting corporations acquire a major role and the function of research and development along with innovation (R&D&i) passes into their hands. "With the Reagan Presidency [1981-1989], the social contract of science was renewed and funding grew again, but based on very different criteria from those of the 1950s and 1960s" (Echeverría 2003 18).

The transition from militarized "macro science" (first stage) to the period of stagnation due to its failure in Vietnam (second stage) led to the emergence of technoscience (third stage). Echeverría Ezponda (2003) does not define technoscience, but examines the concept in authors such as Latour (1992) and Hattois (1999), citing the respective concepts of H. Stork, W. Barret, J. J. Salomon, F. Gros, and J. Ladrière (24-25). He states that:

> Podrían mencionarse otros muchos autores que han subrayado esta convergencia entre ciencia y tecnología, llegando a cuestionar la existencia de fronteras entre ambas. Cuanto más especulativos y ontológicos son dichos filósofos, más tienden a identificar ciencia y tecnología, prescindiendo de las diferencias. El talante reduccionista es muy habitual y en este caso se manifiesta tomando la parte por el todo. La creciente vinculación entre las actividades científicas y tecnológicas es muy cierta. Mas no hay que olvidar que sigue habiendo ámbitos científicos y

> tecnológicos en donde este proceso no se produce. No todo es tecnociencia. Hay diferencias importantes entre la ciencia, la técnica y la tecnología. (25).

This quote suggests that many authors have observed a convergence between science and technology, even questioning if there are clear boundaries between the two. However, some more speculative philosophers tend to identify science and technology without taking into account the significant differences between these areas. This can lead to a reductionist approach that oversimplifies the complexity of these areas. While it is true that the link between science and technology has increased, there are still areas where this convergence does not occur. It is important to remember that not everything is technoscience, and that there are significant differences between science, engineering, and technology.

Echeverría Ezponda adds that he does not intend to define the notion of technoscience. He says that it is not about defining boundaries between science and technoscience, since the latter is a particular type of science. Despite this, the divergent notes that he proposes throughout his text favor making the distinction between the two. He limits himself to approximating technoscience, describing in detail a series of differentiating features between science, technology, and technoscience, taking into account: a) Private funding of research[7]; b) Mutual mediation between science and technology; c) Emerging technoscientific companies in the stock market[8]; d) Research networks through digitally interconnected laboratories; e) Military technoscience; f) New military contract of technoscience; g) Plurality of techno-scientific agents; h) Technoscience and environment; i) Technoscience and society; j) Technoscience and international politics; k) Management of technoscience; l) Technoscience and law; m) Technoscience and values; n) Technoscience and informatics; o) Technoscience and the information and knowledge society.

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[7] It coincides with the birth of neoliberal policies, which promoted economic openness. Thatcher and Reagan formed a personal and political alliance that revitalized the conservative movement worldwide, strengthened strategic cooperation between the United States and the United Kingdom, and ultimately contributed decisively to ending communism and ratifying the universal dominance of capitalism. Thatcher and Reagan coincided in a historical period in which the left's project languished after several decades of internal disputes. While in the United Kingdom, Thatcher revived conservative values against a unionized and bureaucratized Labour Party, in the US, Reagan restored dignity to the right after the Watergate scandal and against a Democratic Party still anchored in the statist ideology of the fifties and sixties.

[8] NASDAQ (National Association of Securities Dealers Automated Quotation) is the second largest automated and electronic stock exchange in the United States, with the New York Stock Exchange being the first, with over 3800 companies and corporations. It is known for including high-tech companies in electronics, computing, telecommunications, biotechnology, and many others.

With what has been exposed, we proceed immediately to elaborate a proposal of a term that can represent the complex set of interactions that articulate the current R&D&i activities, as part of STI, within the current system of international relations of the beginning of the 21st century; that serves for philosophical-scientific reflection and can be used as a conceptual tool for the elaboration of intervention policies in the field of STS.

## Towards Geostrategic Technoscience

Having covered the ground here, the aim now is to move towards a conception of *geostrategic technoscience* that articulates its philosophical and scientific use in the struggle and delimitation of areas of power between nations and corporations, in the distribution of benefits of political influence among them, with corresponding defense and international law systems that legitimize markets for goods and services, thus ensuring the operation mechanisms of companies, their bargaining power with other companies and nation-states, the increase of R&D activities that contribute to sustaining production based on free markets of financial values and products of all kinds. To undertake this task, we proceed to clarify what "geopolitics" means. Next, we will do the same with the concept of "geostrategy," which is intimately linked with the former in an exercise of appropriate conceptual re-elaboration for the present analysis. Then, we will resort to the contributions that Latour and Echeverría Ezponda have made to the concept of "technoscience." With these contributions, we will reconstruct the concept, articulating it with the corresponding concept of "geostrategy," to generate the concept of *geostrategic technoscience*.

### *Concepts of Geopolitics and Geostrategy*

It is not the purpose of this article to delve into the concepts of "geopolitics" and "geostrategy"; the intention is to use them from the most updated theoretical sources, to articulate them with the concept of *technoscience* proposed here. This is part of a dynamic of understanding that aims to interpret the current role of scientific and technological research in the production of goods and services through innovation, understood as a mega-industrial apparatus and activity fused with economic production and defense systems within the

current planetary society, which is an amalgamation of different national societies, in a process of homogenization through the Information and Communication Technologies (ICT) used in the worldwide computer network (web), and normatively legitimized through different States, Treaties between States, and multilateral organizations around the world.[9]

The term "geopolitics" was first introduced in 1905, but it wasn't until the 1930s that it gained relevance through the work of German general Karl Haushofer; his theories popularized the term and the discipline, to the point that Hitler incorporated some of his concepts into the national socialist ideology. This association with Nazism led to a hiatus in the use of the term "geopolitics" for some years, and the discipline was not cultivated due to the negative connotations it conveyed. It wasn't until the 1970s and 1980s that this obstacle was overcome and work resumed in the field of geopolitics, applying the term "geopolitik" to refer to Nazi theorization and distinguish it from the new discipline (Cairo 2011).

From this perspective, traditionally, geopolitics is the study of the effects of the geographic distribution and division of power on the conduct of world politics. In its original sense, it refers to the consequences generated in interstate relations concerning the appropriation and use of spaces, territories of continents and oceans, as well as the distribution and exchange of populations and natural resources. Currently, the term refers at the same time to the analysis of all geographic hypotheses, designations, and understandings involved in the construction of world politics (Agnew 2003).

This is also related to the geography of international relations, particularly the relationship between the natural environment and the conduct of international politics. In explaining the historical development of humanity, political and social concepts have generally been used. However, geopolitical theorists introduced the geographic variable. Geopolitical analysis deals with the realities of permanent power struggles around which international events unfold. Hence, the term geopolitics has been used for a long time as a way of graphically

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[9] There is a wide variety of international courts and tribunals that maintain different levels of relationship with the United Nations. At first instance, there is the International Court of Justice, one of the main organs of the Organization; followed by the ad hoc criminal tribunals established by the Security Council; and, the International Criminal Court and the International Tribunal for the Law of the Sea which were established by conventions developed within the United Nations system, but are now independent entities with special cooperation agreements. Some other international tribunals may be completely independent of the UN.

representing world politics and the practices that sustain it. The change in the geopolitical imaginary goes along with temporal transformations (Agnew 2003).

The change in the geopolitical imaginary goes along with temporal transformations. Such an imaginary has led to expanding the limits of the geopolitical sphere, beyond planetary geography. This is the geopolitics of natural resources regarding the exploration and exploitation of extraterrestrial space by state and private corporate entities. Notably, technoscientific consortia have been investing in space technology research and development since the beginning of the 21st century. This modifies the scenario in which only sovereign states exercised technoscientific, political, legal, and economic competencies, aimed at the characteristics of space, the strategic nature of its control, and the long-term risk investments required to achieve scientific, technological, political, and military competitiveness. This new sphere, in which the characteristics of the market economy and investment allow the participation of private actors, opens an unexplored field for the management of sovereignty concepts and practices, legal limits of ownership of exploitation of space and extraterrestrial natural resources, as well as other aspects considered in traditional geopolitics. Aspects that force philosophical, political, legal, and technoscientific reflection on the role of peripheral and semiperipheral actors in the gap of science, technology, and innovation between the great powers and technoscientific companies (for example: Spacex[10] and Synthetic Genomics[11]) with respect to the majority of less developed states, in function of the new frontier of nature that has emerged (Blinder 2018).

In a critical perspective, the Irish scholar Gearóid Ó Tuathail (1996) reviews the normalized conception of geopolitics, stating that such concept is confusing (49)[12], Eurocentric, and static. He indicates that it is a complex set of discourses, representations, and practices,

[10]SpaceX es a US-based aerospace transportation company founded in 2002 by Elon Musk, who is also a co-founder of other technology and service companies such as PayPal, Tesla Motors, SolarCity, Hyperloop, The Boring Company, Neuralink, and OpenAI. See: https://www.spacex.com/

[11] It is a company founded by Craig Venter, dedicated to the use of genetically modified microorganisms for the production of ethanol and hydrogen as alternative fuels. See: https://syntheticgenomics.com/

[12] One of the most common problems preventing the rigorous theorization of geopolitics is that the term itself is a polysemic one that has long exceeded its original con-textual specification by Kjellen, Haushofer, or even Kissinger. A cursory browse through any of the cites generated by a database search using the term reveals a wide variety of usages and meanings. There are, for example, references to the geopolitics of capitalism, environmentalism, race, urban zoning politics, and cinema, among others. The qualifier "geopolitical" has an even greater range of usage.

instead of a coherent, neutral, and objective science. He asserts that one of the most repeated difficulties that limit rigorous theorization of geopolitics is that the term is polysemic and that its textual original meaning from Kjellen, Haushofer or even Kissinger has gone beyond over time. A quick inquiry through any of the citations generated by a database search using the term displays a wide range of uses and meanings. For example, there are references to the geopolitics of capitalism, environmentalism, race, urban zoning policies, and cinema, among others. The qualifier "geopolitical" has an even broader range of uses. Hence, his interpretation of geopolitics focuses on the interaction and opposition of geopolitical discourses. The facts of the global political space are not revealed to impartial observers; on the contrary, geopolitical knowledge is partial and localized. It results from particular subjective visions associated with the interests of states [and private corporations sheltered by them (Calduch 1991, Sánchez 2008, Lascurain 2012, Romero and Vera 2014)]. Geopolitics frames a wide variety of dramas, conflicts, and dynamics from the perspective of grand strategy. In other words, it is a configuration of actions and discourses that are usually planned but can also be sudden and therefore emergent. This generates the production and results of a dynamic imaginary space-time, so different regions of the world undergo simultaneous demands for spatialization at multiple scales (not necessarily geographical), as well as diverse internal, external, and transversal territorialization experiences to the structure of nation-states and the world-system in Wallerstein's vision (2014). Thus, a new identification and analysis of the main characteristics of spatial practices that (re)produce dominant figurations (the United States and the European Union) or project new spaces of representation (China and Russia, for example) (Blinder 2012) is necessary.

In summary, Ó Tuathail (1996) proposes the need to understand that current geopolitics is developed not associated with a single form of building power but in multiple networks that overlap highly associated with the militarism of powers that are linked to the protection of the interests of private transnational corporations, as noted above. Secondly, he argues for the need to build strategies of resistance to this form of articulation between powers and territories against large economic and military powers, contributing to the decolonization of geographical imagination, giving rise to other geographies, to other possible worlds.

Based on this, the concept of geopolitics can be configured as *a complex set of discourses, representations, and practices of states about the permanent power struggles around which international events develop, associated with demands for spatialization at multiple scales (both geographical and virtual, developed from the use of ICT on the web), as well as diverse internal, external, and transversal territorialization experiences to the structure of such states, to defend their political, economic, and military interests.*

That is to say, geopolitics becomes operational through *geostrategy*. Therefore, the exercise of *geostrategy* could not exist without a background geopolitical vision that determines a direction, in accordance with the goals of political action. *Geostrategy* is the instrumentalization of geopolitics in geographical or virtual spaces within international relations. *Geostrategy* comes from the concept of strategy within states, a concept that is examined below.

> La estrategia, [que es un concepto usado al interior de la política de Estado], es un proceso, una adaptación constante a condiciones y circunstancias cambiantes en un mundo donde el azar, la incertidumbre y la ambigüedad dominan. Aquí se argumenta que casi siempre se requiere que tanto la política como la estrategia sean flexibles y adaptables a las circunstancias cambiantes del contexto. Una política y una estrategia suficientemente buenas siempre deben ser "trabajo en progreso", al menos en un grado modesto. Puede ser difícil argumentar así, sin que, como consecuencia directa, parezca estar peligrosamente dispuesto a eliminar los límites de lo que deberían ser firmes y claras intenciones (Gray 2016).

This quote highlights the importance of flexibility and adaptability in politics and strategy. The author argues that both politics and strategy are continuous processes that require constant adjustments to adapt to the changing conditions and circumstances of the world. Chance, uncertainty, and ambiguity are elements that dominate in the current world, and therefore, it is necessary for both politics and strategy to be flexible and adaptable to succeed in this context. The author also suggests that a good policy and strategy should always be in constant evolution and should not be considered as something static or fixed. However, the author also recognizes that this can be a challenge as it may lead to the elimination of boundaries that should be firm and clear. In summary, the quote emphasizes the importance of adaptability in politics and strategy in a changing and uncertain world.

In addition to the above, it can be said that strategy needs to be interpreted as an articulating element that holds together the intentional activities of the State. Strategy relates all the different behaviors and capabilities that a security collective orders. That is to say, strategy offers the "how" to respond to what, if it did not exist, would be political ambition and military activity, with each isolated from the other. Strategy can be considered a system that allows functional cooperation between categorically distinctive behaviors in order to promote a common purpose. Strategy only has value when it serves as a bridge between purpose and action. All political communities [States] have political preferences and objectives. Additionally, all communities control human, mechanical, and electronic assets that are capable of doing things. What every collective requires are ideas and plans that lead to a promise that is possible to make effective, in the enabling of political means and military capacity, to resist or apply the threat of violence. This is the vital role of strategy. (Gray 2015).

Analogously, geostrategy operates in the same way in the international relations between States, that is, each of the characteristics previously mentioned about strategy in the communities within a State applies to the interactive community between States in the world environment. In other words, here States as individuals and as communities operate in actions arranged towards ends, under behaviors that are identifiable as covert or overt threats, for the attainment of their purposes of influence and hegemony.

Therefore, *geostrategy can be interpreted as a system of actions that facilitates the attainment of a common geopolitical purpose of a State, in the defense, conquest, or imposition of its own political, economic, and military interests, as well as those of its allies; in relation to the maintenance and expansion of its influence and hegemony in the geographical or virtual spaces within international relations.*

*Reworking the concept of Technoscience*

Based on what was presented earlier by Latour and Echeverría Ezponda regarding what is understood as *Technoscience*, we proceed to present an articulated concept that comprehensively considers the different attributes, features, and characteristics of the facts

and experiences that can be collectively labeled with this denomination. This takes into account, briefly, the historical and theoretical relationships between science and technology, along with the component of innovation. With this in mind, the concept of *Technoscience* will be re-elaborated, which will later be articulated with the concept of *Geostrategy,* thus configuring the proposal of *Technostrategic Geostrategy*.

It is clear that the relationship between science and technology has been systematically evolving since the economic, social, and technological transformation of the First Industrial Revolution, which began in the second half of the 18th century. However, this relationship, which was forming, linked the discoveries in the natural sciences with their use in the design and development of all kinds of artifacts, as well as the use of manufactured devices that could facilitate the investigation of the functioning of various phenomena of the natural world, as in the case of the vacuum pump that allowed Boyle to study the behavior of gases (Shapin 1988).

This relationship allowed, over time (19th and 20th centuries), the improvement of living conditions, the increase in production and productivity of industries, transportation, navigation, among many other applications, including the development and innovation of new weapons and military defense systems (Channell 2017), leading to what would later be called the Military-Industrial Complex (Eisenhower 1961, Armeson 1964, Channell 2017). This designation appears in President Dwight Eisenhower's farewell address on January 17, 1961, who warned that a powerful conglomerate had been formed, in which the military industry interested in armaments and American industrial groups, which, as private contractors, were motivated to maintain the arms race between the United States and the Soviet Union (Cold War) for strategic advantage and economic benefit, respectively. Eisenhower warned that this complex between the military and industry manipulated international policy to the detriment of the internal interests of Americans, so it was necessary to be vigilant against any overflow of the reasonable limits of the American nation's project (1961 1035-1040).

The concept of the Military-Industrial Complex is explicitly stated here, as it will be a component of threat and deterrence within the dynamics of international relations, which is

not always visible but is always present in the background of such relations. Within these relations, there is also the flow of Geostrategic Technoscience, as will be explained later.

In the theoretical perspective of the philosophy of science, Niiniluoto (1997) refers to the relationships between science and technology and proposes that five positions are established in the nexus between them: a) technology is ontologically derived from science; b) science ontologically depends on technology; c) science and technology are identical; d) science and technology are independent of each other, both ontologically and causally; and e) science and technology are ontologically independent, but are in causal interaction. Despite this, it is recognized that since the late 19th century, there has been a significant area of overlap, which includes technology based on science and research that incorporates instrumentation (Niiniluoto 1997 290).

Similarly admitting the relationships between science and technology, as Niiniluoto (1997) does, Channell (2017) argues that: "More recently, several scholars have begun to argue that there are areas of scientific and technological development in which science and technology are more than simply interdependent, but in fact, the distinction between science and technology begins to lose meaning" (20)[13]. This theoretical convergence between these two authors necessarily points to the concept of *Technoscience*, which aligns with the perspective that the author of these lines infers from Latour's remarks *on the intertwining of scientific and technological research processes with the technical and administrative organization of research management through large-scale power networks in which humans and artifacts (non-humans with the possibility of acquiring rights) interact within complex organizations of processes within an industrial production machine of goods and services associated with them, which are regulated by a political ecology*. Similarly, it approaches the idea, from an evolutionary perspective, of the sequence that *Little Science*, *Mega Science*, and *Technoscience,* proposed by Echeverría (2003), represent. This philosopher's conception of science is noteworthy, as he points out that: "...many other authors...have emphasized this convergence between science and technology, going so far as to question the existence of

[13] More recently a number of scholars have begun to argue that there are areas of scientific and technological development in which science and technology are more than simply interdependent, but in fact the distinction between science and technology is beginning to become meaningless. (Channel 2017 20).

borders between the two. The more speculative and ontological these philosophers are, the more they tend to identify science and technology, disregarding the differences" (25).

In this line of conceptual articulation, it is necessary to take into account that in the blurring of boundaries between science and technology that is sought here, it is necessary to consider the aspects indicated by Echeverría Ezponda (2003), who, in the opposite sense, has established their differentiation, while at the same time linking the contribution of Latour (2001). An analysis that is developed below.

In this sense, it is worth starting by saying that *Technoscience* has been financed since the late 20th century by the private sector and by public-private partnerships; "this new scientific financial policy succeeded in reversing the percentages of public and private financing of research. [This]…has since become a structural component of the North American [STI] system, which many other countries seek to imitate" (Echeverría 2003 37).

The interlacing between science and technology is complete, since: "If technoscientists intend to produce new knowledge and undertake scientific actions to that end (demonstrate, calculate, observe, measure, experiment, etc.), these actions are literally unfeasible without technological support" (Echeverría 2003 38).

The fusion of technoscientific activity (*technoscience*) with the idea of producing profitable results leads to the idea of permanent business, which implies an organizational and entrepreneurial behavior, ideas and motives that have led to the "obtaining, management, and monetization of patents resulting from R&D, which has become a basic component of technoscientific activity, as important as research itself" (Echeverría 2003 39). Therefore, it is worth noting that technoscientific activity is characterized by the role of innovation that private corporations carry out in the production of goods and services for the international market. As mentioned earlier, this characteristic has led to the appearance of technology companies on the stock exchange.

Since the appearance of ARPANet[14] in the 1960s, which was the network of the US Advanced Research Projects Agency, to which government and academic institutions were gradually added, a process was generated that contributed to the appearance of scientific and

[14] Advanced Research Projects Agency Network

technoscientific networks. These were expanded with developments in electronic and software engineering until the current Internet appeared. This also turned research laboratories into network-laboratories. "In fact, the most elementary scientific actions (obtaining and consulting data, performing calculations, testing hypotheses, exchanging ideas and provisional results, etc.) began to be mediated by the new information and communication technologies (ICTs)" (Echeverría 2003 41). This means that currently, accessing research data and recording new data requires the use of ICTs. Similarly, the publishing industry of scientific publications, including journals, books, and independent articles, is obtained online within the network.

The military forces of different countries, in proportion to their economic and political power, have fully engaged in techno-scientific research. "As a result of the priority given to military technologies, today we can talk about a new form of warfare, information warfare or cyber warfare, based on techno-sciences, rather than the industrialized science of the early 20th century" (Echeverría 2003 43). This signifies the evolution of the actions of the Military-Industrial Complex, as the public-private partnership in the financing of research projects also covers the armed forces sector in various countries. These activities are currently handled as classified information, as they are considered "National Security Matters," as they contain topics related to the security of the State and its citizens, which vary according to the rapid evolutions of the strategic environment and range from defending the territory to economic and financial stability or protecting critical infrastructure of countries.

Since *technoscience* is an activity of enormous magnitude and very complex organization, research projects are developed in the conception of profitable business, within a techno-scientific company or within a conglomerate of such. Currently, "a minimally important techno-scientific company, in addition to scientific researchers, engineers, and technicians, must include other types of teams: managers, advisors, marketing and work organization experts, lawyers, allies in political-military areas, supporting financial entities, etc." (Echeverría 2003 47).

Taking into account, according to Echeverría (2003), that the scenarios of society in which techno-scientific activity unfolds are related to education, research, application, and evaluation of that activity. The relationship between techno-science and society becomes

tense, as different social groups "openly question techno-scientific education, important sectors of society demand social control of techno-scientific research, distrust of expert reports and evaluations... and some of the main techno-scientific innovations are [controversial]" (52). Aspects that place techno-science under discussion, in particular, because of its effects on the environment. In this sense, the author is clear in stating: "... techno-science is not only oriented towards the control and domination of nature, as was the case in Baconian sciences, but it is projected primarily towards the control and domination of societies, as we have already pointed out" (2003 53).

Regarding international relations, techno-science is involved from the guidelines of international policy between states, through multiple agreements for scientific and technological cooperation between national and local governments of different countries on a large number of topics. As an example of this, UNESCO (1999) established a declaration and commitment on science and its use for the 21st century (Budapest Declaration). There, aspects such as science in the service of knowledge, knowledge in the service of progress, science in the service of peace, science in the service of economic and social development, science in society, and science for society were considered.

With the emergence of the so-called "science diplomacy," a new strategy for the influence of technoscience in international relations has opened up. Science diplomacy is an instrument of international policy that is suited to address the central challenges of the globalization era. Traditional diplomacy involves representatives of states handling government affairs with each other, often secretly. However, in recent times, public diplomacy has emerged, which includes the use of dialogue, advocacy, and public relations by envoys to interact directly with foreign populations to influence their governments in an open and publicized manner (Copeland 2011).

Science diplomacy is a subset of public diplomacy. Science diplomacy represents an important source of soft power, that potent form of influence that is based on attraction, that leverages national influence, reputation, and brand. It is a diplomacy with a persuasive character to achieve the objectives of a country or its allies through the benefits of technoscience. Science diplomacy is important for its ability to solve many of the planet's most urgent problems, and also because it is a way to transmit values about knowledge and

its use, such as evidence-based learning, cooperation, openness, and exchange (Copeland 2011). This is how science diplomacy is part of a series of carefully considered actions aimed at a specific goal, using technoscience to satisfy the influence interests of a country or group of countries over another or others, in the distribution and exercise of power with its benefits in the economic, political, and military fields.

Within this context, it is worth adding the issue of the management of *technoscience*, which involves levels of hierarchy, due to the size and complexity of the industrial character of the production of knowledge, devices, and artifacts, which are specific to it. This is because "...within technoscientific teams, research is not only required, but also development and innovation" (Echeverría 2003 55). Characteristics that involve a voluminous and diversified production chain, whose fundamental core is engineering, which articulates and feeds back from the practice of design and planning, the knowledge of the sciences, with the technologies in use, with the industry of goods and services, and with its financing. A production chain in which many professionals are involved, including researchers, engineers, technicians, laboratory staff, administrative personnel, legal agents, marketing professionals, and management teams; all of them are necessary for the achievement of the results of the technoscientific company. "The complex chains of control and evaluation of knowledge production generate enormous bureaucracy, to the point that a good part of the time is spent writing projects, reports, and proposals, increasingly technically complex" (Echeverría 2003 56). It is worth recalling here, as already mentioned above, the concept of the associations that make up human and non-human collectives in a complex organization, the processes of *an industrial production machine* presented by Latour (1992).

In another perspective, it's worth mentioning that since technoscience is involved with the economy through R&D, by means of nomenclature, processes, results, and indicators, aspects contained in various OECD manuals that were mentioned a few pages back; conflicts, divergences, recognition of intellectual property, registration of patents, trademarks, industrial designs, utility models, semiconductor topographies, among others, as well as the economic participation of profits obtained from technoscientific activity, require expert personnel in legal and related procedures. Such participation refers to the internal level of technoscientific companies, as well as inter-company and contract levels between states and

such companies. "Determining the distribution of knowledge ownership is a primarily legal issue. There are many cases where the greatest successes of a project depended on the success of registering and commercializing patents" (Echeverría 2003 57). This leads to what the author himself calls the privatization of knowledge, a characteristic that contrasts with earlier times when the feeling of patriotism and philanthropy towards scientific knowledge was the norm among researchers.

In the field of *technoscience*, scientists and engineers are workers within a production system, with planning that has times, processes, and operations based on the efficiency, effectiveness, and efficacy of results, with their respective publication, which has become a commodity of scientific publishing oligopolies, through the pay-to-view system, download from the web and read (Larivière, Haustein, and Mongeon 2015). Those who affirm the above elaborated an analysis based on 45 million documents indexed in the Web of Science during the period 1973-2013. Thus, both in natural and medical sciences, as well as in social and humanities sciences, Reed-Elsevier, Wiley-Blackwell, Springer, and Taylor & Francis publishing companies increased their participation in published production, especially since the arrival of the digital era, that is, since the mid-1990s. This leads to the interpretation that the privatization of knowledge is another profitable result of *technoscience* from a business perspective.

According to the characteristics previously registered, technoscience currently operates on the platform of information and communication technologies through its operation on the worldwide network of computers, which is being empowered by the latest developments in Artificial Intelligence (A.I.), in fields such as the theory and practice of law to streamline legal processes, making the judicial system more efficient (Yadong Cui 2020), research on distributed systems through A.I. that benefits applications such as the Internet of Things (IoT), e-commerce, mobile communications, wireless devices, among others, all of them high-value-added components with economic, industrial, and research potential, as part of the so-called "Industry 4.0" (Herrera, et al. 2020).

In addition to the use of sophisticated techniques for handling large amounts of data (*Big Data*) as a component of *Data Science*, which are used in R&D, industrial production, and commerce, through cutting-edge engineering approaches in the design, construction, and

deployment of scalable, reliable, and distributed data infrastructures and communication systems (Hemanth, et al. 2020), there is the impending advent of quantum computing (Bernhardt 2019, de Lima Marquezino, Portugal & Lavor 2019, Sutor 2019, Mohamed 2020), which will break current cryptographic security in computing, from online passwords to the backbone of the Internet, necessitating the search for new encryption methods to protect against quantum computer security threats (Grimes 2020). These aspects are related to the current development of quantum hardware, such as Google's Sycamore processor, which takes about 200 seconds to sample an instance of a quantum circuit one million times, whereas the equivalent task for a state-of-the-art classical supercomputer would take approximately 10,000 years according to current benchmarks. This dramatic increase in speed compared to all known classical algorithms is an experimental realization of quantum supremacy for this specific computational task, heralding a long-awaited computational paradigm shift (Arute, et al. 2019).

This revolutionary transformation in computing will require detailed "procedural" guidelines addressing aspects ranging from analysis and design to application implementation, which will need to be integrated into legacy applications and databases. The analysis and design of the next generation of software architectures will have to address new requirements to adapt to the IoT, cybersecurity, *block chain* networks, the cloud, and quantum computing technologies. As wireless 5G technology becomes more established in the coming years, it will demand the migration of legacy applications to these new architectures; this will be crucial for companies [including those producing scientific knowledge and technoscientific devices] to compete efficiently in a consumer-driven, social-network-based economy (Langer 2020, Krishnakumar 2020).

Similarly, the current nature-inspired Data Science solves complex real-world problems in various environmental situations by observing natural phenomena using techniques such as evolutionary computation, swarm intelligence, artificial immune systems, neural networks, among others. This type of computing imitates the behaviors of any biological agent or group, the way they exchange and process information to perform collaborative tasks to achieve a specific goal or make a decision (Rout, et al. 2020, Mirjalili & Dong 2020).

Set of aspects that, together with the privatization of knowledge, have shifted the traditional values of science in modernity, since classical epistemic and technical values inherent to scientific research have now been expanded to also consider economic, legal, political, social, ecological, among other values. This takes into account the deliberate character of technoscientific research, driven by the interests of corporate actors who move international markets, as has been emphasized throughout this article.

As can be observed, the connection between science and technology in a progressive elimination of boundaries has engineering as a leading protagonist. Although there are differences between science and engineering due to their intrinsic characteristics, they are not mutually exclusive. This allows for an integrative perspective of both and synergistically relates them through cybernetic loops that characterize current technologies. These technologies also establish synergistic relationships between Engineering, Industry, and other economic activities, including the production of scientific and technological goods and services (technoscience). This integrative perspective allows for the description of the role of Engineering as a "cybernetic bridge," that is, as a means of integration of systematized information and control between Science, Technology, and Industry, as the ultimate expression of economic activity (technoscience). This integration underlies a mega-system among them, society, and the natural world. The concept of Meta-Engineering, understood as the study and improvement of the technological development process (Callaos 2008), is also worth including in this dynamic.

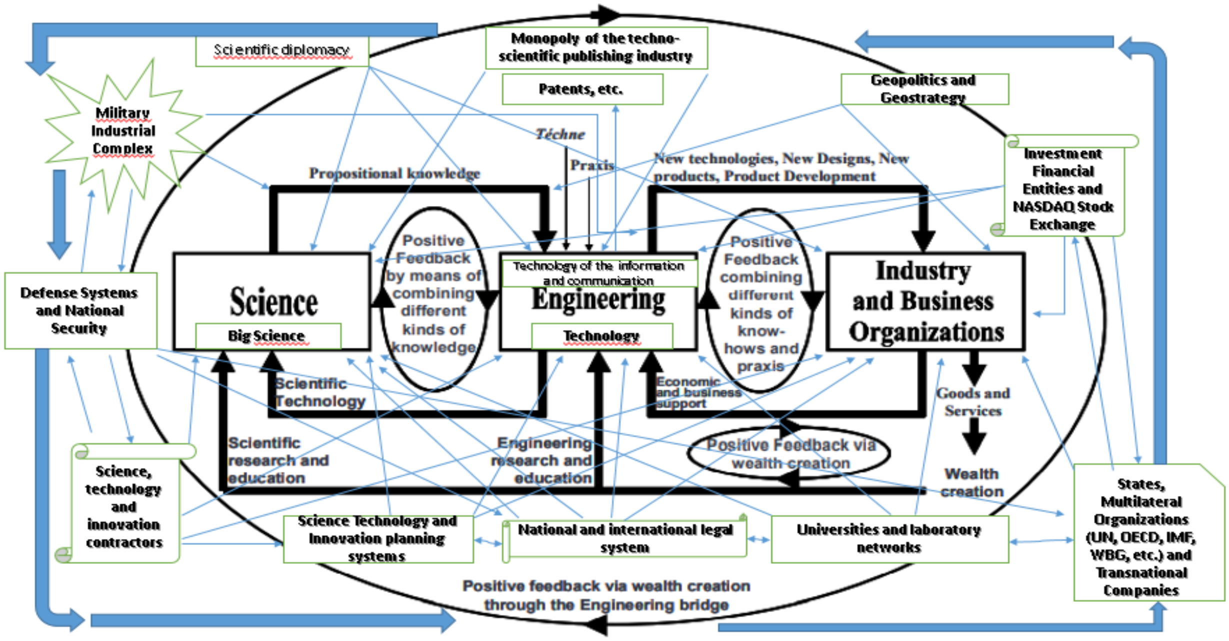
It can then be conceptualized, based on the aforementioned, that *Technoscience is a complex set of interconnections aimed at producing scientific knowledge, optimized artifacts and procedures, systematically digitized through the activities of scientific, technological and innovative research processes, driven by the technical-administrative and financial organization of research management, with specific goals and deterrence military defense systems. It operates through large-scale power networks, in which humans and artifacts (non-humans with A.I.) interact within national and international public organizations, through states and multilateral organizations, legitimized by global legal norms applicable to physical, virtual and cosmic territorial spaces, to support the processes of the mega-intelligent system of dominion and control in the economic-industrial production of goods*

*(devices and artifacts) and services, including scientific and technological knowledge, from a business perspective.*

**Proposal for assembling the concept of Geostrategic Technoscience.**

Taking into account what has been developed so far and assembling a systemic synthesis of the set of descriptions, explanations, and conceptual re-elaborations presented on *technoscience* and *geostrategy,* it can be said that: *Geostrategic Technoscience is a complex set of interconnections for producing scientific knowledge, optimal artifacts and procedures, systematized through ICTs, through activities of scientific research, technological development, and innovation, energized by the technical-administrative and financial organization of research management intended for purposes and with systems of dissuasive military defense; through large-scale networks of power, in which humans and artifacts (non-humans with AI) interact, within the framework of national and international public organizations, through states and multilateral organizations of states, in alliance with transnational private corporations; a framework that is legitimized by global legal norms, applicable to physical, virtual, and cosmic territorial spaces, to support the processes of the mega-intelligent system of dominion and control in the economic-industrial production of goods (devices and artifacts) and services, including scientific and technological knowledge, as well as innovation, in a profitable business perspective; a set that is executed in a network of interactive links, used as a system of actions that facilitates the achievement of common geopolitical purposes of a state, in the defense, conquest, or imposition of its political, economic, and military interests, as well as those of its allies; regarding the maintenance and expansion of its hegemony in the aforementioned spaces, within international relations at the beginning of the 21st century.*

The following graph represents the concept of Geostrategic Technoscience that has been assembled:




Graph 2: Dynamics of the set of intertwined interactions of Geostrategic Technoscience.
Source: Author's elaboration, based on a graph from Callaos 2008.

## Conclusions

In reviewing and analyzing the material for the preparation of this document, a panorama of different lines of study in the philosophy of science has been identified, which can be summarized as follows: a) Many authors have continued to exclusively focus on knowledge and scientific theories, reaffirming the validity of analytic philosophy and insisting that the philosophy of science must be restricted to epistemic issues; a review of the current situation of this trend is well represented in a volume edited by Friedrich Stadler (2010); b) some studies in this first group take into account the history of science, although revising Kuhn's theses, as they are not considered sufficiently rigorous (Echeverría 2003), and some others, in the same line, have focused on the analysis of the philosophies of particular sciences (physics, chemistry, biology, economics, sociology, among others); c) others have been interested in the philosophy of technology, given its importance for scientific research and the ubiquity of ICTs. From this perspective, it is not possible today to do philosophy of science without also doing philosophy of technology (Dusek 2006, de Vries 2016); d) another group has focused on cognitive science and artificial intelligence, replacing old logical formalizations with computational models from cognitive sciences, as long as they are

applicable to the analysis and reconstruction of scientific knowledge (Nowakowska 1986, Clark Glymour, et al. 1987, Jacobson 2013); e) a next group of philosophers, together with scientists from other disciplines, have studied scientific practices as a form of empirical research (naturalized and social). This is the so-called *Philosophy of Science focused on Practices* (Martínez and Huang 2015). One branch with a biological, systemic, and cosmological approach, another tending towards social and cultural approaches; and f) a sixth group has focused on science, technology, and society studies, with a historical perspective, linking philosophy of science and technology, and interested in issues related to transdisciplinary studies (Echeverría 2003 and 2010).

In accordance with this spectrum of trends, the preceding descriptive, explanatory, and reconstructive exercise presented here seeks to open up new avenues of research and reflection in the philosophy of science and technology, in the area of STS, with the proposal of the concept of *Geostrategic Technoscience,* since it promotes the linking of geostrategic relations between different nations considered as powers in the philosophical-scientific-technical reflection, in terms of the production of scientific knowledge, technological development, and innovation of products, given the existence of a current mega-industrial production complex that articulates scientific and technological knowledge in the dynamics of corporate economic production, national defense systems, and international legal-political relations between states, among many other links. This implies that what is presented here is just a set of initial ideas that require further detailed study and must be addressed by various transdisciplinary working groups to advance in a critical comparative analysis.

This does not deny the existence of conceptual tools such as *Little Science*, *Big Science*, *technology*, and *technoscience*, all of which represent socially identifiable and theoretically recognizable practices. The concept of *Geoastrategic Technoscience* does not aim to displace or encompass the aforementioned tools, but rather provides an alternative epistemic perspective, one that is complex and systemic, to interpret the dynamics of current events and knowledge in this field.

The philosophy of science needs to avoid becoming a kind of museum of ideas, where authors and approaches that made valuable contributions in the 20th century are cultivated and maintained. While due respect and attention are given to these individuals and positions, the

transformations of the past 30 years in the world, including science, technology, and societies in general, require new perspectives, reflections, and courses of action in this field. The philosophy of science needs to take these changes into account, opening new lines of study and delving into those that are less explored. This work is an effort to contribute to this endeavor.

Finally, it is hoped that this proposal, which serves to represent the interrelated dynamics of R&D, an expression of STI, within the field of STS as an object of study in the philosophy of science and technology, can contribute to further analysis, leading to calls for and actions toward international intervention on indicators of crisis in the current civilization, in order to modify the triggering of events that are not desirable for a good and synergistic life on the planet.

**References**


Agnew, John. (2003). *Geopolitics.* Re-visioning world politics. Second edition. Routledge. Taylor & Francis. London and New York.

Armeson, Robert. (1964). *Total Warfare and Compulsory Labor.* A study of the Military-Industrial Complex in Germany during World War I. The Hague/ Martinus Nijhoff/ Netherlands.

Arute, Frank, et al. (2019). "Quantum supremacy using a programmable superconducting processor". *Nature*, Vol 574, pp. 505-510. https://www.nature.com/articles/s41586-019-1666-5

Bachelar, Gastón. (1953). *Le Matérialisme Rationnale.* Les Presses universitaires de France, Paris. 3e édition, 1972. Collection: Nouvelle encyclopédie philosophique, 225 pages. 1re édition, 1953.

Bernhardt, Chris. (2019). *Quantum Computing for Everyone.* Massachusetts Institute of Technology (MIT). Cambridge, Massachusetts.

Bernstein, Jeremy. (2001). *Hitler´s Uranium Club.* The secret recordings at Farm Hall. Springer Science+Business Media. New York.

Blinder, Daniel. (2012). "Armas espaciales: Vieja agenda de seguridad internacional y tecnologías de punta". *Política y Estrategia.* No. 120. Julio-Diciembre, pp. 123-152. https://www.researchgate.net/publication/321845782_ARMAS_ESPACIALES_VIEJA_AGENDA_DE_SEGURIDAD_INTERNACIONAL_Y_TECNOLOGIAS_DE_PUNTA

Blinder, Daniel. (2018). "Geopolítica y recursos naturales espaciales". *Paakat: Revista de Tecnología y Sociedad.* Universidad de Guadalajara. Sistema de Universidad Virtual. México, pp. 1-18. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S2007-36072018000300085

Bourdieu, Pierre. (1976). "Le champ scientifique". *Actes de la recherche en sciences sociales*. Vol. 2, n°2-3, juin 1976. La production de l'idéologie dominante. pp. 88-104. https://www.persee.fr/doc/arss_0335-5322_1976_num_2_2_3454

Bush, Vannevar. (1945). *Science, the endless frontier*. A report to the President on a program for postwar scientific research. Reprinted, July 1960. National Science Foundation. Washington, D.C. Recuperado en: https://apo.org.au/sites/default/files/resource-files/1945/07/apo-nid62466-1240581.pdf

Cairo, Heriberto. (2011). "La Geopolítica como «ciencia del Estado»: el mundo del general Haushofer". *Geopolítica(s). Revista de estudios sobre espacio y poder*, 2011. Vol. 3, núm. 2, 337-345. Recuperado en: https://eprints.ucm.es/39839/1/la%20geopolitica%20como%20ciencia%20del%20estdo%20el%20mundo%20del%20general%20Haushoher.pdf

Calduch, Rafael. (1991). *Relaciones Internacionales.* Capítulo 12: Los actores transnacionales (II): Las empresas multinacionales. Edit. Ediciones Ciencias

Sociales. Madrid. Recuperado en: https://www.ucm.es/rrii-e-historia-global/libro-relaciones-internacionales

Callaos, Nagib. (2010). *The Essence of Engineering and Meta-Engineering: A work in Progress.* Universidad Simon Bolivar, and The Institute of Systemics, Cybernetics and Informatics. Recuperado en: https://www.researchgate.net/publication/242073115_The_Essence_of_Engineering_and_Meta-Engineering_A_Work_in_Progress

Channell, David. (2017). *A History of Technoscience.* Erasing the Boundaries between Science and Technology. History and Philosophy of Technoscience. Number 12. Series Editor: Alfred Nordmann. Routledge. London and New York.

Copeland, Daryl. (2011). “Science Diplomacy: What’s It All About?”. *CEPI-CIPS.* Policy Brief 13. November, 2011. University of Ottawa. Recuperado en: http://cips.uottawa.ca/wp-content/uploads/2011/11/Copeland-Policy-Brief-Nov-11-5.pdf

Crim, Brian E. (2018). *Our Germans*. Project Paperclip and the National Security State. Johns Hopkins University Press. Baltimore.

De Lima Marquezino, Franklin., Portugal, Renato. & Lavor, Carlile. (2019). *A Primer on Quantum Computing.* Springer Nature Switzerland AG.

Durbin Paul. et al. (1983). *Philosophy and Technology*. (Boston studies in the philosophy of science; v. 80). D. Reidel Publishing Company, P.O. Box 17, 3300 AA Dordrecht, Holland.

Dusek, Val. (2006). *Philosophy of Technology. An Introduction*. Blackwell Publishing. 350 Main Street, Malden, MA 02148-5020, USA 9600. Garsington Road, Oxford OX4 2DQ, UK 550 Swanston Street, Carlton, Victoria 3053, Australia.

de Vries, Marc J. (2016). *Teaching about Technology. An Introduction to the Philosophy of Technology for Non-philosophers.* 2nd Edition. Springer International Publishing Switzerland.

Echeverría Ezponda, Javier. (2003). *La revolución tecnocientífica*. Fondo de Cultura Económica FCE. Madrid.

Echeverría Ezponda, Javier. (2015) “De la filosofía de la ciencia a la filosofía de la tecnociencia”. *Revista CTS, nº 28, vol. 10, enero de 2015 (pág. 109-119).*

Eisenhower, Dwight. (1961). *Farewell Radio and Television Adrees to American People.* January 17, 1961 [Delivered from President´s Office at 8:30 p.m.]. In: *Public Paper of the Presidents of the United States.* Published by the Office of the Federal Register. National Archives and Records Service. General Service Administration. Washington, D. C. Pages 1035-1040.

Ellul, Jacques. (1964). *The technological society.* Vintage Books. Alfred A. Knopf, Inc. and Random House, Inc. New York.

Ellul, Jacques. (1980). *The technological system*. The Continuum Publishing Corporation. New York.

Ellul, Jacques. (1990). *The technological bluff.* Grand Rapids, MI: Eerdmans.

Galison, Peter. (2008). “Ten Problems in History and Philosophy of Science”. *Isis*. No. 99:111–124.

García Díaz, Paloma. (2008). “Los límites del principio de indeterminación radical en Latour y el giro político de su filosofía de la ciencia”. *THEORIA* 63 / pp. 319-336.

Gatica, Obed Frausto. (2015). “La sociología de la ciencia y la reflexividad científica”. *Revista Acta Sociológica*. Número 67, mayo-agosto. pp. 193-220.

Gimbel, John. (1990a). “German Scientists, United States Denazification Policy, and the 'Paperclip Conspiracy'”. *The International History Review*, Aug. Vol. 12, No. 3, pp. 441-465. Published by: Taylor & Francis, Ltd. Stable URL: http://www.jstor.com/stable/40106226

Gimbel, John. (1990b). *Science, Technology, and Reparations*. Exploitation And Plunder In Postwar Germany. Stanford University Press Stanford, California.

Gimbel, John. (1986). “U.S. Policy and German Scientists: The Early Cold War”. *Political Science Quarterly*. Vol. 101, No. 3, pp. 433-451. Published by: The Academy of Political Science Stable URL: https://www.jstor.org/stable/2151624

Glymour, Clark., Schemes, Richard., Spirtes, Peter and Kelly, Kevin. (1987). *Discovering Causal Structure.* Artificial Intelligence, Philosophy of Science, and Statistical Modeling. Department of Philosophy Carnegie Mellon University Pittsburgh, Pennsylvania. Academic Press, Inc. Orlando, Florida.

Gómez Mata, María José. (2013). “Fenomenotécnica: Bachelard y el giro práctico en la Filosofía de la Ciencia”. *Revista ArtefaCToS*, vol. 6, n.º 1, diciembre, pp. 65-80.

Gray, Colin. (2015). *The future of strategy.* First published in 2015 by Polity Press. Polity Press 65 Bridge Street Cambridge CB2 1UR, UK.

Gray, Colin. (2016). *Strategy and Politics*. Routledge. Taylor & Francis Group. London and New York.

Grimes, Roger A. (2020). *Cryptography Apocalypse: Preparing for the Day When Quantum Computing Breaks Today’s Crypto.* Published by John Wiley & Sons, Inc. 111 River Street Hoboken, NJ 07030.

Habermas, Jürgen. (1999). *Ciencia y Técnica como “Ideología”*. Tecnos, Madrid.

Hacking, Ian. (1996). *Representar e Intervenir.* Paidós. México, Buenos Aires, Barcelona.

Hattois, Gilbert. (2000). “La technoscience: entre technophobie et technophilie”. *Universite de touts les Savoirs*. Les conférences de l'année 2000. https://streaming-canal-u.fmsh.fr/vod/media/canalu/documents/utls/download/pdf/190100.pdf

Hemanth, Jude., Bathia, Madhulika. & Geman, Oana. (Editors). (2020). *Data Visualization and Knowledge Engineering.* Springer Nature Switzerland AG.

Herrera, Francisco., Matsui, Kenji. & Rodríguez-González, Sara. (Editors). (2020). *Distributed Computing and Artificial Intelligence, 16th International Conference.* Springer Nature Switzerland.

Hottois, Gilbert. (1991). *El paradigma bioético. Una ética para la tecnociencia.* Barcelona: Anthropos,

Hunt, Linda. (1985). "U.S. coverup of Nazi scientists". *Bulletin of the Atomic Scientists,* Vol. 41: No. 4, 16-24.

Jacobsen, Annie. (2014). *Operation Paper Clip.* The Secret Intelligence Program That Brought Nazi Scientist To America. Little, Brown and Company. New York.

Jacobson, Anne Jaap. (2013). *Keeping the World in Mind.* Mental Representations and the Sciences of the Mind. University of Houston, USA. Palgrave Macmillan. New York.

Joly, Caroline. (2013). *La technoscience: au-delà du renversement du rapport hiérarchique entre la science et la technique.* En: La technoscience et ses enjeux Les transformations théoriques et empiriques de la science et du risque. Pages 31-52. Les éditions libres du Carré Rouge. Quebec.

Jonas, Hans. (1995). *El principio de responsabilidad.* Ensayo de una ética para la civilización tecnológica. Editorial Herder. Barcelona.

Krishnakumar, Arunkumar. (2020). *Quantum Computing and Blockchain in Business.* Exploring the applications, challenges, and collision of quantum computing and blockchain. Published by Packt Publishing Ltd. Livery Place 35 Livery Street Birmingham B3 2PB, UK.

Langer, Arthur M. (2020). *Analysis and Design of Next-Generation Software Architectures*. 5G, IoT, Blockchain, and Quantum Computing. Center for Technology Management, Columbia University, New York, NY, USA. Springer Nature Switzerland AG.

Larivière, Vincent, Haustein, Stefanie, Mongeon, Philippe. (2015). "The Oligopoly of Academic Publishers in the Digital Era". *PLoS ONE* 10(6): e0127502. doi:10.1371/ journal.pone.0127502.

Larrión, Jósean. (2019). "Teoría del actor-red. Síntesis y evaluación de la deriva postsocial de Bruno Latour". *Revista Española de Sociología,* 28 (2), pp. 323-341.

Lascurain Fernández, Mauricio. (2012). "Empresas multinacionales y sus efectos en los países menos desarrollados". *Economía: Teoría y Práctica.* Nueva Época, Número 36, enero-junio. http://www.scielo.org.mx/pdf/etp/n36/n36a4.pdf

Latour, Bruno. (1988a). *Science in Action: How to Follow Scientists and Engineers through Society.* Harvard University Press. 1988.

Latour, Bruno. (1988b) *The Pasteurization of France*, Cambridge (MA), Harvard University Press.

Latour, Bruno. (1991). *La tecnología es la sociedad hecha para que dure*. En: Sociología simétrica. Ensayos sobre ciencia, tecnología y sociedad. Editado por: Domènech, Miquel and Tirado, Francisco Javier. Barcelona: Gedisa editorial, pp. 109-142.

Latour, Bruno y Woolgar, Steve. (1995). *La vida en el laboratorio.* La construcción de los hechos científicos. Alianza Universidad. Madrid.

Latour, Bruno. (2000). *Pandora´s Hope.* Essays on the Reality of Science Studies. Harvard University Press. Cambridge, Massachusetts. London, England.

Latour, Bruno. (2001). *La Esperanza de Pandora*. Ensayos sobre la realidad de los estudios de la ciencia. Gedisa Editorial, Barcelona.

Latour, Bruno. (2008). *Reensamblar lo social*. Una introducción a la Teoría del Actor-Red. Manantial, Buenos Aires.

Leydesdorff, Loet. (2010). "The Knowledge-Based Economy and the Triple Helix Model". *Annual Review of Information Science and Technology*. Volume 44, Issue1. Pages 365-417.

Leydesdorff, Loet & Meyer, Martin. (2003). "The Triple Helix of University-Industry-Government Relations". *Scientometrics*. Vol. 58, No. 2, pp. 191-203. https://link.springer.com/content/pdf/10.1023%2FA%3A1026276308287.pdf

Marcuse, Herbert. *Some Social Implications of Modern Technology*. In: Studies in Philosophy and Social Sciences Vol. IX, pp. 138-163. (1941).

Marcuse, Herbert. *Industrialisierung und Kapitalismus*. In O. Stammer (Hrsg.), Max Weber und die Soziologie heute: Verhandlungen des 15. Deutschen Soziologentages in Heidelberg 1964 (S. 161-180). Tübingen: Mohr Siebeck (1965). Recuperado en: https://www.ssoar.info/ssoar/bitstream/handle/document/35270/ssoar-1965-marcuse-Industrialisierung_und_Kapitalismus.pdf?sequence=1&isAllowed=y&lnkname=ssoar-1965-marcuse-Industrialisierung_und_Kapitalismus.pdf

Martínez, Sergio y Huang, Xiang. (2015). *Hacia una filosofía de la ciencia centrada en prácticas.* Bonilla Artigas Editores / Instituto de Investigaciones Filosóficas – UNAM, México.

Martins, Herminio. (1998). "Technology, modernity, politics". *The Politics of Postmodernity*. Edited by James Good and Irving Velody. Cambridge University Press, pp. 150-181. New York, 1998.

Mirjalili, Seyedali. & Dong, Jin Song. (2020). *Multi-Objective Optimization using Artificial Intelligence Techniques.* Springer Nature Switzerland AG.

Mitcham, Carl. (1989). *¿Qué es la Filosofía de la Tecnología?* Anthropos, Barcelona.

Mitcham, Carl. (1994). *Thinking Through Technology*. The Path between Engineering and Philosophy. University of Chicago Press. Chicago and London.

Nowakowska, Maria. (1986). *Cognitive Sciences*. Basic Problems, New Perspectives, and Implications for Artificial Intelligence. Machine Intelligence Institute Iona College New Rochelle, New York. Academic Press, Inc. New York.

Nowotny, Helga., Scott, Peter. & Gibbons, Michael. (2001). *Re-Thinking Science. Knowledge and the Public in an Age of Uncertainty*. Polity Press in association with Blackwell Publishers, a Blackwell Publishing Company. Cambridge, UK. Malden MA. USA.

Mohamed, Khaled Salah. (2020). *Neuromorphic Computing and Beyond: Parallel, Approximation, Near Memory, and Quantum.* Springer Nature Switzerland AG.

Monterroza, Álvaro. (2017). "Una revisión crítica a la teoría del Actor-red para el estudio de los artefactos". *Trilogía: Ciencia Tecnología Sociedad*. Vol. 9, No. 17. Julio-Diciembre / pp. 49-62.

Nowotny, Helga. (2015). “The radical openness of science and innovation”. *EMBO reports*. Vol 16. No 12. https://www.embopress.org/doi/pdf/10.15252/embr.201541546

Niiniluoto, Ilka. (1997). “Ciencia frente a Tecnología: ¿Diferencia o identidad?” *Revista Arbor*. Consejo Superior de Investigaciones Científicas. CLVII, 620 (agosto), pp. 285-299.

OCDE. (2015). *Frascati Manual 2015*: Guidelines for Collecting and Reporting Data on Research and Experimental Development , The Measurement of Scientific, Technological and Innovation Activities. Publicado por acuerdo con la OCDE, París. https://minciencias.gov.co/sites/default/files/manual_de_frascati_web_0_1.pdf

OECD. (2020). *Organisation for European Economic Co-operation*. http://www.oecd.org/general/organisationforeuropeaneconomicco-operation.htm

OECD/Eurostat (2018), *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation*, 4th Edition, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris/Eurostat, Luxembourg. https://www.oecd-ilibrary.org/docserver/9789264304604-en.pdf?expires=1588599311&id=id&accname=guest&checksum=7BFB6E9E441836B2FD1AFB5C0D0A1FF7

Ó Tuathail, Gearóid. (1996). *Critical Geopolitics. The Politics of Writing Global Space.* Routledge. London.

Pickering, Andrew. (1993). “The Mangle of Practice: Agency and Emergence in the Sociology of Science”. *American Journal of Sociology*, Vol. 99, No. 3 (nov.), pp. 559-589. Published by: The University of Chicago Press. Stable URL: http://www.jstor.org/stable/2781283

Pozas, María de los Ángeles. (2015). *En busca del actor en la Teoría del Actor Red.* I Congreso Latinoamericano de Teoría Social. Instituto de Investigaciones Gino Germani. Facultad de Ciencias Sociales, Universidad de Buenos Aires, Buenos Aires. https://www.aacademica.org/000-079/51

Price, D. J. de Solla. (1963). *Little Science, Big Science.* Columbia University Press. New York and London.

Price, D. J. de Solla. (1973). *Hacia una Ciencia de la Ciencia*. Editorial Ariel. Barcelona.

Price, D. J. de Solla. (1986). *Little science, big science and beyond*. Columbia University Press New York Guildford, Surrey.

Romero, Alberto y Vera, Analí. (2014). “Las empresas transnacionales y los países en desarrollo”. *TENDENCIAS. Revista de la Facultad de Ciencias Económicas y Administrativas*. Universidad de Nariño Vol. XV. No. 2 – 2do. Semestre, Julio-Diciembre. Páginas 58-89.

Rout, Minakhi., Rout, Jitendra Kumar. & Das, Himansu. (Editors). (2020). *Nature Inspired Computing for Data Science*. Springer Nature Switzerland AG.

RYCIT-OEA. (2001). *Manual de Bogotá.* Normalización de Indicadores de Innovación Tecnológica en América Latina y el Caribe. Bogotá. http://www.ricyt.org/wp-content/uploads/2019/09/bogota-1.pdf

Samuel, Wolfgang W. E. (2004). *American Raiders.* The Race To Capture The Luftwaffe´s Secrets. University Press Of Mississippi / Jackson.

Sánchez, Joan-Eugeni. (2008). *El poder de las empresas multinacionales*. Diez años de cambios en el Mundo, en la Geografía y en las Ciencias Sociales, 1999-2008. Actas del X Coloquio Internacional de Geocrítica, Universidad de Barcelona, 26-30 de mayo de 2008. http://www.ub.es/geocrit/-xcol/449.htm

Shapin, Steven. (1988). "The House of Experiment in Seventeenth-Century England." *Isis*, Vol. 79, No. 3, A Special Issue on Artifact and Experiment (Sep.), pp. 373-404. https://www.jstor.org/stable/234672?origin=JSTOR-pdf&seq=1

Simondon, Gilbert. *Du mode d'existence des objets techniques*. Editions Aubier. 1989.

Simondon, Gilbert. (2005). *L´Invention dans les tecniques.* Cours et Conférences. Éditions du Seuil. Paris.

Simondon, Gilbert. (2014). *Sur la technique* (1953-1983). Presses Universitaires de France. Paris.

Stadler, Friedrich (Editor). (2010). *The Present Situation in the Philosophy of Science*, Institute Vienna Circle. University of Vienna. Vienna, Austria. Heidelberg, Springer.

Sutor, Robert S. (2019). *Dancing with Qubits.* How quantum computing works and how it can change the world. Published by Packt Publishing Ltd. Livery Place 35 Livery Street Birmingham B3 2PB, UK.

UNESCO. (1999). *Declaración sobre la ciencia y el uso del saber científico.* Science for the Twenty First Century. A new commitment. World Conference on Science. 1 de julio. http://www.unesco.org/science/wcs/esp/declaracion_s.htm

Walker, Charles Lester. (1946) "Secrets by the thousands". *Harper's Magazine*. October, pp. 329-336. https://archive.org/details/harpersmagazine193alde/page/328/mode/2up

Wallerstein, Immanuel. (2014). *El moderno Sistema mundial.* Primera Edición. México. Siglo XXI. 4 Volúmenes.

Weinberg, Alvin. (1961). "Impact of Large-Scale Science on the United States". *Science*. New Series, Vol. 134, No. 3473 (Jul. 21), pp. 161-164. http://www.jstor.org/stable/1708292

Yadong, Cui. (2020). *Artificial Intelligence and Judicial Modernization.* Shanghai Law Society. Translated by Cao Yan and Liu Yan. Shanghai, China. Springer Nature Singapore Pte Ltd. 2020.